

# Annex B

## Methodology for Estimating Emissions of CH<sub>4</sub>, N<sub>2</sub>O, and Criteria Pollutants from Stationary Sources

### Estimates of CH<sub>4</sub> and N<sub>2</sub>O Emissions

Methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O) emissions from stationary source fuel combustion were estimated using IPCC emission factors and methods. Estimates were obtained by multiplying emission factors (by sector and fuel type) by fossil fuel and wood consumption data. This “top-down” methodology is characterized by two basic steps, described below. Data are presented in Table B-1 through Table B-5.

#### Step 1: Determine Energy Consumption by Sector and Fuel Type

Greenhouse gas emissions from stationary combustion activities were grouped into four sectors: industrial, commercial/institutional, residential, and electric utilities. For CH<sub>4</sub> and N<sub>2</sub>O, estimates were based upon consumption of coal, gas, oil, and wood. Energy consumption data were obtained from EIA’s *Monthly Energy Review* (1998b), and adjusted to lower heating values assuming a 10 percent reduction for natural gas and a 5 percent reduction for coal and petroleum fuels. Table B-1 provides annual energy consumption data for the years 1990 through 1997.

#### Step 2: Determine the Amount of CH<sub>4</sub> and N<sub>2</sub>O Emitted

Activity data for each sector and fuel type were then multiplied by emission factors to obtain emissions estimates. Emission factors were taken from the *Revised 1996 IPCC Guidelines* (IPCC/UNEP/OECD/IEA 1997). Table B-2 provides emission factors used for each sector and fuel type.

### Estimates of NO<sub>x</sub>, CO, and NMVOC Emissions

For criteria pollutants, the major source categories included were those identified in EPA (1998): coal, fuel oil, natural gas, wood, other fuels (including bagasse, liquefied petroleum gases, coke, coke oven gas, and others), and stationary internal combustion (which includes emissions from internal combustion engines not used in transportation). EPA (1998) periodically estimates emissions of NO<sub>x</sub>, CO, and NMVOCs by sector and fuel type using a “bottom-up” estimating procedure. In other words, the emissions were calculated either for individual sources (e.g., industrial boilers) or for many sources combined, using basic activity data (e.g., fuel consumption or deliveries, etc.) as indicators of emissions. EPA (1998) projected emissions for years subsequent to their bottom-up estimates. The national activity data used to calculate the individual categories were obtained from various sources. Depending upon the category, these activity data may include fuel consumption or deliveries of fuel, tons of refuse burned, raw material processed, etc. Activity data were used in conjunction with emission factors that relate the quantity of emissions to the activity. Table B-3 through Table B-7 present criteria pollutant emission estimates for 1990 through 1997.

The basic calculation procedure for most source categories presented in EPA (1998) is represented by the following equation:

$$E_{p,s} = A_s \times Ef_{p,s} \times (1 - C_{p,s}/100)$$

where,

E = emissions

p = pollutant

s = source category

A = activity level

EF = emission factor

C = percent control efficiency

The EPA currently derives the overall emission control efficiency of a category from a variety of sources, including published reports, the 1985 National Acid Precipitation and Assessment Program (NAPAP) emissions

inventory, and other EPA databases. The U.S. approach for estimating emissions of NO<sub>x</sub>, CO, and NMVOCs from stationary combustion as described above is similar to the methodology recommended by the IPCC (IPCC/UNEP/OECD/IEA 1997).

**Table B-1: Fuel Consumption by Stationary Sources for Calculating CH<sub>4</sub> and N<sub>2</sub>O Emissions (Tbtu)**

Fuel/End-Use Sector	1990	1991	1992	1993	1994	1995	1996	1997
<b>Coal</b>	<b>18,935.3</b>	<b>18,698.6</b>	<b>18,802.1</b>	<b>19,428.0</b>	<b>19,497.8</b>	<b>19,567.0</b>	<b>20,448.3</b>	<b>20,921.1</b>
Residential	61.9	56.3	56.7	56.6	55.5	53.7	55.1	55.1
Commercial/Institutional	92.9	84.5	85.7	85.5	83.5	81.0	83.1	83.1
Industry	2,692.7	2,545.4	2,467.7	2,444.8	2,463.7	2,441.9	2,357.3	2,303.0
Utilities	16,087.8	16,012.4	16,192.0	16,841.1	16,895.2	16,990.5	17,952.7	18,480.0
<b>Petroleum</b>	<b>11,741.5</b>	<b>11,389.6</b>	<b>11,696.4</b>	<b>11,641.5</b>	<b>11,928.7</b>	<b>11,489.4</b>	<b>12,000.2</b>	<b>12,356.8</b>
Residential	1,266.3	1,293.3	1,312.4	1,387.0	1,340.4	1,363.0	1,440.9	1,466.9
Commercial/Institutional	906.9	860.6	813.3	752.8	753.3	756.8	740.9	730.9
Industry	8,317.9	8,057.8	8,637.7	8,449.6	8,866.8	8,711.6	9,093.6	9,337.0
Utilities	1,250.4	1,177.8	933.0	1,052.0	968.2	658.0	724.9	822.0
<b>Natural Gas</b>	<b>18,597.9</b>	<b>18,983.5</b>	<b>19,530.1</b>	<b>20,257.1</b>	<b>20,612.1</b>	<b>21,479.2</b>	<b>21,817.8</b>	<b>21,843.9</b>
Residential	4,518.7	4,685.0	4,821.1	5,097.5	4,988.3	4,981.3	5,382.9	5,145.6
Commercial/Institutional	2,698.1	2,807.7	2,884.2	2,995.8	2,980.8	3,112.9	3,243.5	3,373.1
Industry	8,519.7	8,637.2	8,996.3	9,419.6	9,590.2	10,108.6	10,393.7	10,285.5
Utilities	2,861.4	2,853.6	2,828.5	2,744.1	3,052.9	3,276.4	2,797.7	3,039.7
<b>Wood</b>	<b>2550.0</b>	<b>2577.0</b>	<b>2709.0</b>	<b>2696.0</b>	<b>2740.7</b>	<b>2741.5</b>	<b>2864.0</b>	<b>2625.9</b>
Residential & Commercial	581.0	613.0	645.0	592.0	582.0	641.0	643.8	475.1
Industrial	1947.5	1942.8	2042.4	2083.5	2138.2	2083.5	2200.5	2131.5
Utilities	21.5	21.2	21.6	20.5	20.5	17.0	19.8	19.3

**Table B-2: CH<sub>4</sub> and N<sub>2</sub>O Emission Factors by Fuel Type and Sector (g/GJ)<sup>4</sup>**

Fuel/End-Use Sector	CH <sub>4</sub>	N <sub>2</sub> O
Coal		
Residential	300	1.4
Commercial/Institutional	10	1.4
Industry	10	1.4
Utilities	1	1.4
Petroleum		
Residential	10	0.6
Commercial/Institutional	10	0.6
Industry	2	0.6
Utilities	3	0.6
Natural Gas		
Residential	5	0.1
Commercial/Institutional	5	0.1
Industry	5	0.1
Utilities	1	0.1
Wood		
Residential	300	4.0
Commercial/Institutional	300	4.0
Industrial	30	4.0
Utilities	30	4.0

<sup>4</sup> GJ (Gigajoule) = 10<sup>9</sup> joules. One joule = 9.486×10<sup>-4</sup> Btu

**Table B-3: NO<sub>x</sub> Emissions from Stationary Sources (Gg)**

<b>Sector/Fuel Type</b>	<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>
<b>Electric Utilities</b>	<b>6,045</b>	<b>5,914</b>	<b>5,901</b>	<b>6,034</b>	<b>5,956</b>	<b>5,792</b>	<b>5,497</b>	<b>5,605</b>
Coal	5,119	5,043	5,062	5,211	5,113	5,061	5,027	5,079
Fuel Oil	200	192	154	163	148	87	94	120
Natural gas	513	526	526	500	536	510	239	262
Wood	NA	NA	NA	NA	NA	NA	NA	NA
Internal Combustion	213	152	159	160	159	134	137	144
<b>Industrial</b>	<b>2,754</b>	<b>2,703</b>	<b>2,786</b>	<b>2,859</b>	<b>2,855</b>	<b>2,852</b>	<b>2,876</b>	<b>2,967</b>
Coal	530	517	521	534	546	541	543	557
Fuel Oil	240	215	222	222	219	224	223	218
Natural gas	1,072	1,134	1,180	1,207	1,210	1,202	1,212	1,256
Wood	NA	NA	NA	NA	NA	NA	NA	NA
Other Fuels <sup>a</sup>	119	117	115	113	113	111	113	118
Internal Combustion	792	720	748	783	767	774	784	818
<b>Commercial/Institutional</b>	<b>336</b>	<b>333</b>	<b>348</b>	<b>360</b>	<b>365</b>	<b>365</b>	<b>366</b>	<b>379</b>
Coal	36	33	35	37	36	35	35	36
Fuel Oil	88	80	84	84	86	94	93	97
Natural gas	181	191	204	211	215	210	212	219
Wood	NA	NA	NA	NA	NA	NA	NA	NA
Other Fuels <sup>a</sup>	31	29	25	28	28	27	26	27
<b>Residential</b>	<b>749</b>	<b>829</b>	<b>879</b>	<b>827</b>	<b>817</b>	<b>813</b>	<b>804</b>	<b>779</b>
Coal <sup>b</sup>	NA	NA	NA	NA	NA	NA	NA	NA
Fuel Oil <sup>b</sup>	NA	NA	NA	NA	NA	NA	NA	NA
Natural Gas <sup>b</sup>	NA	NA	NA	NA	NA	NA	NA	NA
Wood	42	45	48	40	40	44	44	31
Other Fuels <sup>a</sup>	708	784	831	787	777	769	760	748
<b>Total</b>	<b>9,884</b>	<b>9,779</b>	<b>9,914</b>	<b>10,080</b>	<b>9,993</b>	<b>9,822</b>	<b>9,543</b>	<b>9,729</b>

NA (Not Available)

<sup>a</sup> "Other Fuels" include LPG, waste oil, coke oven gas, coke, and non-residential wood (EPA 1998).

<sup>b</sup> Coal, fuel oil, and natural gas emissions are included in the "Other Fuels" category (EPA 1998).

Note: Totals may not sum due to independent rounding.

**Table B-4: CO Emissions from Stationary Sources (Gg)**

<b>Sector/Fuel Type</b>	<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>
<b>Electric Utilities</b>	<b>329</b>	<b>317</b>	<b>318</b>	<b>329</b>	<b>335</b>	<b>338</b>	<b>357</b>	<b>368</b>
Coal	213	212	214	224	224	227	225	230
Fuel Oil	18	17	14	15	13	9	10	11
Natural gas	46	46	47	45	48	49	69	71
Wood	NA	NA	NA	NA	NA	NA	NA	NA
Internal Combustion	52	41	43	46	50	52	53	56
<b>Industrial</b>	<b>798</b>	<b>835</b>	<b>867</b>	<b>946</b>	<b>944</b>	<b>958</b>	<b>972</b>	<b>1,007</b>
Coal	95	92	92	92	91	88	90	91
Fuel Oil	67	54	58	60	60	64	65	66
Natural gas	205	257	272	292	306	313	316	329
Wood	NA	NA	NA	NA	NA	NA	NA	NA
Other Fuels <sup>a</sup>	253	242	239	259	260	270	277	288
Internal Combustion	177	189	205	243	228	222	224	233
<b>Commercial/Institutional</b>	<b>205</b>	<b>196</b>	<b>204</b>	<b>207</b>	<b>212</b>	<b>211</b>	<b>227</b>	<b>235</b>
Coal	13	13	13	14	13	14	14	14
Fuel Oil	16	16	16	16	16	17	17	17
Natural gas	40	40	46	48	49	49	49	51
Wood	NA	NA	NA	NA	NA	NA	NA	NA
Other Fuels <sup>a</sup>	136	128	128	129	134	132	148	152
<b>Residential</b>	<b>3,668</b>	<b>3,965</b>	<b>4,195</b>	<b>3,586</b>	<b>3,515</b>	<b>3,876</b>	<b>3,867</b>	<b>2,759</b>
Coal <sup>b</sup>	NA	NA	NA	NA	NA	NA	NA	NA
Fuel Oil <sup>b</sup>	NA	NA	NA	NA	NA	NA	NA	NA
Natural Gas <sup>b</sup>	NA	NA	NA	NA	NA	NA	NA	NA
Wood	3,430	3,711	3,930	3,337	3,272	3,628	3,622	2,520
Other Fuels <sup>a</sup>	238	255	265	249	243	248	244	239
<b>Total</b>	<b>4,999</b>	<b>5,313</b>	<b>5,583</b>	<b>5,068</b>	<b>5,007</b>	<b>5,383</b>	<b>5,424</b>	<b>4,369</b>

NA (Not Available)

<sup>a</sup> "Other Fuels" include LPG, waste oil, coke oven gas, coke, and non-residential wood (EPA 1998).

<sup>b</sup> Coal, fuel oil, and natural gas emissions are included in the "Other Fuels" category (EPA 1998).

Note: Totals may not sum due to independent rounding.

**Table B-5: NMVOC Emissions from Stationary Sources (Gg)**

<b>Sector/Fuel Type</b>	<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>
<b>Electric Utilities</b>	<b>43</b>	<b>40</b>	<b>40</b>	<b>41</b>	<b>41</b>	<b>40</b>	<b>44</b>	<b>46</b>
Coal	25	25	25	26	26	26	25	26
Fuel Oil	5	5	4	4	4	2	3	3
Natural gas	2	2	2	2	2	2	7	7
Wood	NA	NA	NA	NA	NA	NA	NA	NA
Internal Combustion	11	9	9	9	9	9	9	9
<b>Industrial</b>	<b>165</b>	<b>177</b>	<b>169</b>	<b>169</b>	<b>178</b>	<b>187</b>	<b>189</b>	<b>197</b>
Coal	7	5	7	5	7	5	5	5
Fuel Oil	11	10	11	11	11	11	11	11
Natural gas	52	54	47	46	57	66	66	70
Wood	NA	NA	NA	NA	NA	NA	NA	NA
Other Fuels <sup>a</sup>	46	47	45	46	45	45	46	48
Internal Combustion	49	61	60	60	58	59	60	62
<b>Commercial/Institutional</b>	<b>18</b>	<b>18</b>	<b>20</b>	<b>22</b>	<b>21</b>	<b>21</b>	<b>21</b>	<b>22</b>
Coal	1	1	1	1	1	1	1	1
Fuel Oil	3	2	3	3	3	3	3	3
Natural gas	7	8	9	10	10	10	10	10
Wood	NA	NA	NA	NA	NA	NA	NA	NA
Other Fuels <sup>a</sup>	8	7	7	8	8	8	8	8
<b>Residential</b>	<b>686</b>	<b>739</b>	<b>782</b>	<b>670</b>	<b>657</b>	<b>726</b>	<b>724</b>	<b>515</b>
Coal <sup>b</sup>	NA	NA	NA	NA	NA	NA	NA	NA
Fuel Oil <sup>b</sup>	NA	NA	NA	NA	NA	NA	NA	NA
Natural Gas <sup>b</sup>	NA	NA	NA	NA	NA	NA	NA	NA
Wood	651	704	746	633	621	689	687	478
Other Fuels <sup>a</sup>	35	35	36	36	36	37	37	37
<b>Total</b>	<b>912</b>	<b>975</b>	<b>1,011</b>	<b>901</b>	<b>898</b>	<b>973</b>	<b>978</b>	<b>780</b>

NA (Not Available)

<sup>a</sup> "Other Fuels" include LPG, waste oil, coke oven gas, coke, and non-residential wood (EPA 1998).

<sup>b</sup> Coal, fuel oil, and natural gas emissions are included in the "Other Fuels" category (EPA 1998).

Note: Totals may not sum due to independent rounding.